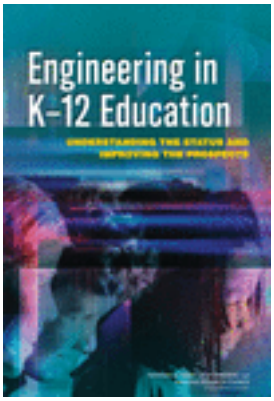

Engineering in K-12 Education: Understanding the Status and Improving the Prospects

Linda Katehi, Greg Pearson, and Michael Feder, Editors; Committee on Kâ€“12 Engineering Education; National Academy of Engineering and National Research Council

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Appendix B

Curriculum Projects—Descriptive Summaries

The Academy of Engineering

The Academy of Engineering (AOE) is a mobile engineering laboratory that combines hands-on activities with either Fischertechnik® or LEGO® manipulatives to teach students science, technology, engineering, math, architecture, communications, and robotics. According to the company, AOE includes hundreds of hours of course work and activities. Versions appropriate to elementary, middle, and high school are available. The program also includes online teacher training, student assessment and support, and a virtual online community that includes quarterly engineering challenges, and at-home extension activities. The curriculum is comprised of four volumes of real-world mechanical engineering projects that naturally embed mathematics, design, technology literacy, communications, and science. The volumes address simple machines, power transfer, gear trains, and principles of robotics and each book provides enough materials to cover an entire semester.

Developer: PCS Edventures Inc.
Website: http://edventures.com/imssc/nsimssc/
To Obtain Materials: Contact Sales and Product Information at 800/429-3110 or sales@pcsedu.com

Children Designing & Engineering

Children Designing & Engineering was a collaboration between the College of New Jersey's Department of Technological Studies, the New Jersey Chamber of Commerce, and the Institute of Electrical and Electronics Engineers. With funding from the National Science Foundation, the project developed contextual learning units for children in grades K–2 and 3–5. Each unit is framed in the context of a prominent New Jersey business (i.e., Six Flags Wild Safari, Lucent Technologies, Marcal Paper, Public Service Electric and Water, Elizabethtown Water, Johnson & Johnson, Ocean Spray). They are designed to run from four to six weeks (or 15 to 22 hours), and they begin with a design challenge that must be addressed in the final week. The subsequent instruction enables students to develop a solution to the challenge by engaging them in researching topics, generating ideas, planning courses of action, making things, and testing and presenting their designs. Addressing these challenges requires students to apply concepts and skills from mathematics, science, technology, and other academic subjects.

Developer: The College of New Jersey
Contact: Alison Goeke
E-mail: goeke2@tcnj.edu
To obtain materials: Materials out of print.

DTEACh

DTEACh (Design Technology and Engineering for America's Children) is a product of the Cockrell School of Engineering at The University of Texas at Austin. It began in 1992 as a grassroots science, technology, engineering, and mathematics teacher education project for elementary school teachers. In 2000, DTEACh began partnering with National Instruments to offer robotics and automation workshops using LEGO MINDSTORMS. Over the past eight years, the program has helped hundreds of Central Texas educators integrate cutting-edge technology into the classroom through the DTEACh Robotics and Automation Summer Institutes. Participants learn to use the engineering design process to more effectively teach state-mandated science and math standards. Mentors from the engineering community held these teachers use LEGO MINDSTORMS to engage their students in learning that integrates core STEM subjects while incorporating 21st century skills. DTeach has one published curriculum, for grades 3–4, on automation and control.

Developer: Cockrell School of Engineering, The University of Texas at Austin
Website: www.engr.utexas.edu/dteach
Contact: Cheryl Farmer
E-mail: cheryl.farmer@mail.utexas.edu
To obtain materials: The curriculum on automation and control can be downloaded at http://www.engr.utexas.edu/dteach/resources/DTEACh_Robotics_3-5.pdf

Engineering: An Introduction for High School

Engineering: An Introduction for High School is an open-source high school "flexbook" created using software developed by the CK–12 Foundation by engineering and education faculty at Arizona State University. The flexbook format allows the book to be customized for multiple audiences. The text can be updated, expanded, and repurposed as necessary to support specific standards and classroom needs. The current draft has four content chapters that cover the nature of engineering, engineering and society, engineering design, and the connection between engineering, science, and mathematics.

Developer: Faculty at Arizona State University
Contact: Darryl Morrell
E-mail: DARRYL.MORRELL@asu.edu
To obtain materials: http://flexbooks.ck12.org

Engineering by Design™

Engineering byDesign™ (EbD) is a national model program developed by the ITEA-CATTS (International Technology Education Association-Center to Advance the Teaching of Technology and Science) Consortium in consultation with the ITEA Technology Education Advisory Council, ITEA institutional members, and the mathematics, science, and engineering communities. At the K–5 grades, the program provides content that can be integrated with other school subjects. In grades 6–12, the program offers nine discrete courses, ranging in length from 18 weeks to 36 weeks. Engineering by Design™ is built on the constructivist model, and students in the program learn concepts and principles in an authentic, problem-based environment. A network of technology teachers (EbD™ Network) has been selected to collaborate and conduct action research (through eTIDEonline™ and the EbD Online Assessment & Design Challenge) in order to better understand the complexities of student learning and to help all students succeed and be prepared for the global society in which they will grow up.

Developer: International Technology Education Association
Website: http://www.iteaconnect.org/EbD/ebd.htm
Contact: Barry Burke
E-mail: bburke@iteaconnect.org
Materials available to members of the ITEA-CATTS Consortium.

Engineering Your Future: A Project-Based Introduction to Engineering
Engineering Your Future: A Project-Based Introduction to Engineering is a high-school level, project-based introduction to engineering. The 19-chapter text includes information related to the history of technology and engineering; engineers and the engineering profession; the big ideas in engineering, including systems, optimization, problem solving, design, and modeling; technology, society, and ethics; and fundamental mathematical and physics concepts used in mechanical and electrical engineering. There are 43 case studies that engage students in various types of learning activities. An instructor's guide can also be purchased.

Developers: Alan Gomez, William Oakes, Les Leone
Contact: Al Gomez
E-mail: aggomez@spasd.k12.wi.us
To obtain materials: Great Lakes Press, Paul Bruner (paul@glpbooks.com) or 800-837-0201

Engineers of the Future

Engineers of the Future is a set of eight middle and high school courses modeled on the design and technology curriculum of the United Kingdom and intended for use by technology education teachers in the United States. The course are (1) Introduction to Design, Engineering and Technology for Middle School; (2) Foundations of Design, Innovation, Engineering and Technology for High School; (3) Engineering Design and Product Development for MS and HS; (4) Exploring our Designed World; (5) Pro/Desktop Designing and Modeling for MS or HS; (6) Pro Engineering and Prototyping for HS; (7) Introduction to Biotechnology and Bioengineering; and (8) Introduction to Digital Electronics and Control Systems. According to the developers, the courses and accompanying professional development experiences are meant to complement and enhance the delivery of integrated STEM education. The courses were piloted in New York in 2007. Partners in the effort include Buffalo State College, Technology Department; the New York State Education Department; PTC Corporation; and the MIT Consortium.

Developer: Buffalo State College, Technology Department
Website: http://www.buffalostate.edu/technology/eof.xml
Contact: Steve Macho
E-mail: machos@buffalostate.edu

Exploring Designing and Engineering

Exploring Designing and Engineering (ED&E)™, initially funded by the New Jersey Commission on Higher Education, offers teacher professional development and instructional materials that are contextual, problem-based, and authentic. Six-week units for grades 6-8 focus on science and technology integration in "Pack It Up, Ship It Out"; "Community by Design"; "Materials & Processes," and "The Big Thrill—Dream It, Plan It, Build It." High School units include "Digital DJ," "Ready, Set, Sail," "Xtreme Automata" and the "Capstone Course" for advanced students. *Design and Engineering with ProDESKTOP*, ED&E's classroom text, guides students through the skills of computer-aided design and visualization used in the ED&E units. Over 500 New Jersey teachers have taken ED&E workshops since 2000, with nearly 15,000 students now participating in design and engineering activities statewide.

Developer: The College of New Jersey, Center for Mathematics, Science, Technology and Pre-Engineering
Website: http://njtqe-r.grant.tcnj.edu/index.htm
Contact: John Karsnitz
E-mail: karsnitz@tcnj.edu

The Infinity Project (Middle School)

The Infinity Project introduced its middle school (grades 6–8) engineering curriculum in fall 2008. It consists of six three-week modules developed in partnership with engineering professors at Southern Methodist University and middle school educators. Modules can be grouped together and offered as a standalone course or individually incorporated into existing math, science, or technology classes. Additional modules spanning the disciplines of electrical, mechanical, civil, environmental, and biomedical engineering will be introduced in fall 2009.

The initial six modules are:

- Introduction to Engineering Design
- Rocketry—Achieving Liftoff I
- Rocketry—Achieving Liftoff II
- Robots from Concept to Completion
- Sound Engineering—Making Great Sounds
- Engineering in the Natural World

Schools must apply to become an Infinity Project school and offer the middle school engineering curriculum. Once accepted into the program, teachers attend week-long training during the summer. Professional development materials include instructor notes, homework solutions, sample test questions, a daily lesson plan guide, PowerPoint chapter lectures, and online support.

Developer: The Infinity Project, Southern Methodist University
Contact: Dianna McAtee
E-mail: dmcatee@infinity-project.org

Insights: An Inquiry-Based Elementary School Science Curriculum (Structures Module)

Insights: An Inquiry-Based Elementary School Science Curriculum was developed by a coalition of science curriculum specialists at Education Development Center, Inc. and teams of elementary school teachers from Baltimore, Boston, Cleveland, Los Angeles, New York, Montgomery County (Maryland), and San Francisco school districts. Each module was pilot tested by team teachers, revised, field tested on a larger scale, and revised a second time before publication. The Center for the Study of Testing, Evaluation, and Educational Policy (CSTEEP) at Boston College provided evaluation and assessment specialists for the project. In the Structures Module, sixth grade students begin to develop an understanding of some of the basic principles that answer the question, Why do structures stand up? They look at structures in the school neighborhood, observing the variety in size, shape, material, and function. They build their own structures, using straws, index cards, and other materials. As they build, students explore some of the basic concepts of standing structures, such as live load, dead load, tension and compression, the role of shapes, and trusses. By comparing their structures with those in their community, students learn how structure and design are influenced by function, materials, and aesthetics. The last activity in the module challenges students to design and construct a unique piece of playground equipment.

Developer: Center for Science Education, Education Development Center, Inc.
Website: http://cse.edc.org/curriculum/insightsElem/
Contact: Karen Worth
E-mail: kworth@edc.org
To obtain materials: Kendall/Hunt Publishing Company, 800-542-6657, ext. 1042, or orders@kendallhunt.com

INSPIRES: INcreasing Student Participation, Interest and Recruitment in Engineering and Science

INSPIRES is a collaborative project between the University of Maryland Baltimore County and University of Maryland School of Medicine. It is funded through a grant from the National Science Foundation. The curriculum has five units:

- Engineering in Health Care
- Engineering and Flight
- Engineering and the Environment
- Engineering in Communications and Information Technology
- Engineering Energy Solutions

INSPIRES aims to provide students with hands-on experiences and inquiry-based learning with "real world" engineering design exercises. The materials target the ITEA Standards for Technological Literacy as well as national standards in science and mathematics. In addition, the project includes in-service training with curriculum and professional development opportunities for technology education teachers prior to classroom use. A specific objective is to increase the involvement of women and other underrepresented groups in engineering and technology by providing role modes in the classroom and developing case studies that encourage interest and participation by all groups.

Developers: UMBC and UMSM
Contact: Julia Ross
E-mail: jross@umbc.edu

Learning by Design

Learning by Design is a project-based inquiry approach to science for middle school students (grades six through eight). This initiative is housed at the Georgia Institute of Technology and funded by the National Science Foundation, the BellSouth Foundation, the James S. McDonnell Foundation, and the Robert W. Woodruff Foundation. The thrust of the project is to help students "learn science content deeply" in conjunction with developing the "skills and understanding needed to undertake solution of complex, ill-structured problems." Students study science in the context of addressing design challenges that help them make connections between their experiences, science concepts and skills, and the world around them. During the design process, they practice designing and running experiments, analyzing data and drawing conclusions, making informed decisions and justifying them with evidence, working collaboratively in a team, and communicating ideas and experiences to others. Each unit requires students to "publicly describe to their peers what they've done and how they've been reasoning, allowing the teacher and their peers to hear their reasoning and help them around hurdles." The units of instruction center on designing parachutes, erosion management systems, model vehicles, lifting devices, and subway tunnels.

Developer: Georgia Institute of Technology
Website: http://www.cc.gatech.edu/projects/lbd/home.html
Contact: Janet Kolodner
E-mail: jlk@cc.gatech.edu

LEGO® Engineering

LEGO Engineering, a collaboration between the Tufts Center for Engineering Education Outreach and LEGO Education, offers five fully developed curriculum modules based on LEGO design projects. Each module consists of a set of class sessions, with each session building upon previous learning. Modules include lesson plans, teacher resource documents, student handouts, and assessment materials. Four of the modules are designed for grades 3–5: Design a Musical Instrument: The Science of Sound, Design a Model House: The Properties of Materials, Design an Animal Model: Animal Studies, and Design a People Mover: Simple Machines. The fifth module, Robotics: Assistive Devices for the Future, is intended for grades 6–8. All five modules were developed with funding from the National Science Foundation. The LEGO Engineering website also contains a number of discrete Lego design activities, sequences of these activities, and video tutorials (podcasts).

Developers: Center for Engineering Educational Outreach, Tufts University, and LEGO Education
Website: www.legoengineering.com
Contact: Merredith Portsmore
E-mail: merredith@legoengineering.com
To obtain materials: Curriculum resources are downloadable for free from the LEGO Engineering website.

Principles of Engineering

Principles of Engineering (PoE) was a major curriculum project developed under the auspices of the New York State Education Department in 1989, field tested in 65 school districts across New York State from 1989 to 1992, and revised in 1995. PoE was a one-year high school course targeted to students in grades 11 and 12 who had completed two years of Regents level mathematics and two years of Regents level science, preferably including physics. The course included a set of hands-on, laboratory-based case studies and was taught in a laboratory setting, providing students access to tools and materials for individual, small-group, and large-group projects. The case studies addressed auto safety, ergonomics of communication technology, machine automation, structural design, and designing for people with disabilities. Engineering concepts addressed in the course included design, modeling, systems, optimization, technology-society interactions, and engineering ethics. After field testing, a National Science Foundation grant provided funding to disseminate the course nationally through a series of professional development workshops. Teachers from 20 states participated in these workshops.

Developer: New York State Department of Education
Contact: Michael Hacker
E-mail: Michael.Hacker@hofstra.edu
To obtain materials: This curriculum is out of print.

TeachEngineering.org

TeachEngineering.org is a collaborative project between faculty, students and teachers associated with five universities and the American Society for Engineering Education, with funding from the NSF National Science Digital Library. TeachEngineering.org is a searchable, web-based digital library collection populated with standards-based engineering curricula for use by K–12 teachers and engineering faculty to make applied science and math (engineering) come alive in K–12 settings. The collection provides access to a growing curricular resource of multi-week units, lessons, activities and living labs. Materials on the site are organized according to 43 subject areas, each containing related curricular units, lessons, and activities. The site allows users to determine the extent to which a given unit, lesson, or activity is consistent with individual state or national-level educational standards. Initiated by the merging of K–12 engineering curricula created by four universities, the collection continues to grow and evolve over time with new additions from other universities, and input from teachers who use the curricula in their classrooms.

Developer: Multi-university collaboration, ASEE
Website: http://www.teachengineering.org/
Contact: Jackie Sullivan
Email: jacquelyn.sullivan@colorado.edu
To obtain materials: Materials downloadable free from the website.

TECH-Know

The TECH-Know curriculum was developed by North Carolina State University and is a standards-based curriculum adapted from 20 technology-based problems issued by the Technology Student Association (TSA). There are 10 units each for middle and high school classrooms. The following topics are covered in the middle school units:

- Agricultural/Biotechnology
- Cyberspace Pursuit
- Dragster Design Challenge
- Environmental Challenge
- Flight Challenge
- Mechanical Challenge
- Structural Challenge
- Transportation Challenge
- Medical Technology Challenge
- Digital Photography

The following topics are covered in the middle school units:

- Desktop Publishing
- Film/Video Technology
- Manufacturing Prototype
- Radio Controlled Vehicle Transportation
- SciVis
- Structural Engineering
- System Control Technology
- Technology Challenge
- Medical Technologies
- Agricultural and Biotechnologies

Developer: North Carolina State University
Website: http://www.ncsu.edu/techknow/aboutproject.html
Contact: Jerianne Taylor or Rosanne White
Contact e-mail: taylorjs@appstate.edu; rwhite@tsaweb.org
To obtain materials: Materials out of print.

Technology Education: Learning by Design

Technology Education: Learning by Design is a middle school textbook developed by the Center for Technological Literacy at Hofstra University. The text uses the "informed design" approach, which encourages research, inquiry, and analysis; fosters student and teacher discourse; and cultivates language proficiency. The book contains seven units:

- The Nature of Technology
- Design for a Technological World
- Materials, Manufacturing, and Construction
- Communication and Information Technology
- Energy, Power, and Transportation
- Biological and Chemical Technology
- The Future of Technology in Society

Also available are a student activity guide, annotated teacher's edition, teacher's resource binder, test bank with ExamView CD-ROM, and a technology timeline poster.

Developer: Center for Technological Literacy, Hofstra University
Contact: David Burghardt
E-mail: M.D.Burghardt@hofstra.edu
To obtain materials: Pearson Prentice Hall, k12cs@custhelp.com or 800/848-9500

What is Engineering?

What is Engineering? originated as an introduction to engineering class offered to first semester freshmen at Johns Hopkins University (JHU). JHU adapted the course so it could be taught as a summer program aimed at rising high school juniors and seniors as well as incoming college freshmen. The class is an intensive four-week experience where students actively participate in hands-on team activities including laboratory experiments and virtual Internet-based simulations while attending college-level lectures related to these activities. Field trips to local companies that employ engineers and informational sessions on college and career choices are integrated into the course schedule. The curriculum links math, science, and engineering concepts to practical problems as a means of teaching students the essential problem-solving skills required to be a successful engineer. Students may earn college credit from JHU for participating in the class. Course locations include Maryland, California, New Mexico, and Pennsylvania. In California, several of Engineering Innovations' sites are offered in partnership with MESA (Mathematics Engineering Science Achievement) program.

Developer: Johns Hopkins University, Whiting School of Engineering
Contact: Lindsay Carroll (Program Manager) or Michael Karweit (Academic Director)
E-mail: lindsay.carroll@jhu.edu or mjk@jhu.edu
To obtain materials: http://engineering-innovation.jhu.edu

A World in Motion® (High School)

A World In Motion® (High School), developed by SAE International, is an activities-based curriculum focused on electricity and electronics. Student teams conduct in-depth experiments involving transistors and semiconductors, analog integrated circuits, and digital integrated circuits. As with other World in Motion® curricula, the high school program requires teachers to work with a volunteer classroom mentor from a science, engineering or technical profession. World in Motion® has the goal of increasing student interest in math and science. SAE International provides the AWIM curriculum and materials at no cost to classroom teachers who complete a Statement of Partnership.

Developer: SAE International
Website: http://www.sae.org/exdomains/awim/
Contact: Matt Miller
E-Mail: matt.miller@sae.org
To obtain materials: AWIM hotline, 1-800-457-2946